GEN-2016-017

Impact Restudy for Generator Modification

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By SPP Generator Interconnections Dept.

REVISION HISTORY

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION
02/28/2020	SPP	Initial report issued.

CONTENTS

SUMMARY

The GEN-2016-017 Interconnection Customer has requested a modification to its 250.7 MW Interconnection Request. This system impact restudy was performed to determine the effects of changing turbines from 109 GE 2.3 MW wind turbine generators (for a total of 250.7 MW) to 92 GE 2.72 MW wind turbine generators (for a total of 250.24 MW). In addition, the modification request included changes to the collection system, generation interconnection line, main substation transformer and GSU transformers. The point of interconnection (POI) for GEN-2016-017 remains at the on the Fort Thompson to Leland Olds 345 kV line.

This study was performed by Aneden Consulting to determine whether the request for modification is considered Material. A low-wind/no-wind condition analysis and impedance analysis was performed for this modification request. The study report follows this executive summary.

The generating facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VArs) in accordance with FERC Order 827. Additionally, the project will be required to install approximately 12.9 MVArs of reactor shunts on the 34.5 kV bus of the generator project substation or provide an alternate means of reactive power compensation. This is necessary to offset the capacitive effect on the transmission network caused by the project's transmission line and collector system during low-wind/no-wind conditions.

The requested modification is not considered Material as there were not any identified impacts to costs, timing, or system reliability.

It should be noted that this study analyzed the requested modification to change generator technology and layout. Powerflow and stability analysis were not performed. It is likely that the customer may be required to reduce its generation output to 0 MW, also known as curtailment, under certain system conditions to allow system operators to maintain the reliability of the transmission network.

Nothing in this study should be construed as a guarantee of transmission service or delivery rights. If the customer wishes to obtain deliverability to final customers, a separate request for transmission service must be requested on Southwest Power Pool's OASIS by the customer.

A: CONSULTANT'S MATERIAL MODIFICATION STUDY REPORT

See next page for the Consultant's Material Modification Study report.

Aneden Consulting

Submitted to

Southwest Power Pool

SPP Southwest Power Pool

Report On

GEN-2016-017
Modification Request Impact Study

Revision R1

Date of Submittal
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anedenconsulting.com

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Executive Summary

Aneden Consulting (Aneden) was retained by the Southwest Power Pool (SPP) to perform a Modification Request Impact Study (Study) for GEN-2016-017, an active generation interconnection request with a point of interconnection (POI) on the Fort Thompson to Leland Olds 345 kV line.

The GEN-2016-017 project is proposed to interconnect in the Basin Electric Power Cooperative (BEPC) control area with a capacity of 250.7 MW as shown in Table ES-1 below. This Study has been requested to evaluate the modification of GEN-2016-017 to change turbine configuration to a total of 92 x GE 2.72 MW wind turbines for total capacity of 250.24 MW. In addition, the modification request included changes to the collection system, generator step-up transformer, main substation transformer, and the generation interconnection line. The modification request changes are shown in Table ES-2 below.

Table ES-1: GEN-2016-017 Existing Configuration

Request	Capacity (MW)	Existing Generator Configuration	Point of Interconnection
GEN-2016-017	250.7	109 x GE 2.3MW = 250.7 MW	G16-017-TAP (560074) on Fort Thompson (652806) - Leland Olds (659424) 345 kV Line

Table ES-2: GEN-2016-017 Modification Request

Facility	Existing	Modification	
Point of Interconnection	G16-017-TAP (560074) on Fort Thompson (652806) - Leland Olds (659424) 345 kV Line	G16-017-TAP (560074) on Ft. Thompson (652806) - Leland Olds (659424) 345 kV Line	
Configuration/Capacity	109 x GE 2.3MW = 250.7 MW	92 x GE 2.72MW = 250.24 MW	
Generation Interconnection Line	Length = 0.5 miles R = 0.000027 pu X = 0.000255 pu B = 0.003100 pu	Length = 0.066 miles (350 feet) R = 0.0000036 pu X = 0.0000338 pu B = 0.0004110 pu	
Main Substation Transformer	X = 10%, R = 0.24%, Winding 170 MVA, Rating 280 MVA	X = 9.5%, R = 0.17%, Winding 84 MVA, Rating 140 MVA	X = 9.5%, R = 0.17%, Winding 84 MVA, Rating 140 MVA
GSU Transformer	Gen 1 Equivalent Qty: 109: X = 5.69%, R = 0.8%, Rating 279.04 MVA	Gen 1 Equivalent Qty: 46: X = 5.68%, R = 0.71%, Rating 144.26 MVA	Gen 2 Equivalent Qty: 46: X = 5.68%, R = 0.71%, Rating 144.26 MVA
Equivalent Collector Line	R = 0.003549 pu X = 0.005016 pu B = 0.101990 pu	R = 0.006619 pu X = 0.008577 pu B = 0.063178 pu	R = 0.006601pu X = 0.009188 pu B = 0.064461 pu

The modification request retained the same GE wind turbine technology and as such, the equivalent impedances from the POI up to and including the step-up transformers for GEN-2016-017 were calculated before and after the modification request. The modification request resulted in a change in the equivalent impedances of approximately 1.03%. As a result, the scope of this modification request study was limited to the reactive power analysis (low wind) analysis.

Aneden performed a reactive power analysis using the modification request data based on the DISIS-2016-002 ReStudy #1 Group 15 study models:

1. 2017 Winter Peak (2017WP),
2. 2018 Summer Peak (2018SP), and
3. 2026 Summer Peak (2026SP).

All analyses were performed using the PTI PSS/E version 33.7 software and the results are summarized below.

A power factor analysis was not performed as there was no change in the point of interconnection for GEN-2016-017.

The results of the reactive power analysis, also known as the low-wind/no-wind condition analysis, performed using the 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak models showed that the GEN-2016-017 project may require a 12.9 MVAr shunt reactor on the 34.5 kV bus of the project substation. The shunt reactor is needed to reduce the reactive power transfer at the POI to approximately zero during low/no wind conditions while the generation interconnection project remains connected to the grid.

1.0 Introduction

Aneden Consulting (Aneden) was retained by the Southwest Power Pool (SPP) to perform a Modification Request Impact Study (Study) for GEN-2016-017, an active generation interconnection request with a point of interconnection (POI) on the Fort Thompson to Leland Olds 345 kV line.

The GEN-2016-017 project is proposed to interconnect in the Basin Electric Power Cooperative (BEPC) control area with a combined capacity of 250.7 MW as shown in Table 1-1 below. Details of the modification request is provided in Section 2.0 below.

Table 1-1: GEN-2016-017 Existing Configuration

Request	Capacity (MW)	Existing Generator Configuration	Point of Interconnection
GEN-2016-017	250.7	109 x GE 2.3MW = 250.7 MW	G16-017-TAP (560074) on Fort Thompson (652806) - Leland Olds (659424) 345 kV Line

1.1 Scope

The Study included an equivalent impedance comparison and a reactive power analysis. The methodology, assumptions, and results of the analyses are presented in the following four main sections:

1. Project and Modification Request
2. Equivalent Impedance Comparison
3. Reactive Power Analysis
4. Conclusions

Aneden performed a reactive power analysis using a set of modified study models developed using the modification request data and the three DISIS-2016-002 ReStudy #1 Group 15 study models:

1. 2017 Winter Peak (2017WP),
2. 2018 Summer Peak (2018SP), and
3. 2026 Summer Peak (2026SP).

All analyses were performed using the PTI PSS/E version 33.7 software. The results of each analysis are presented in the following sections.

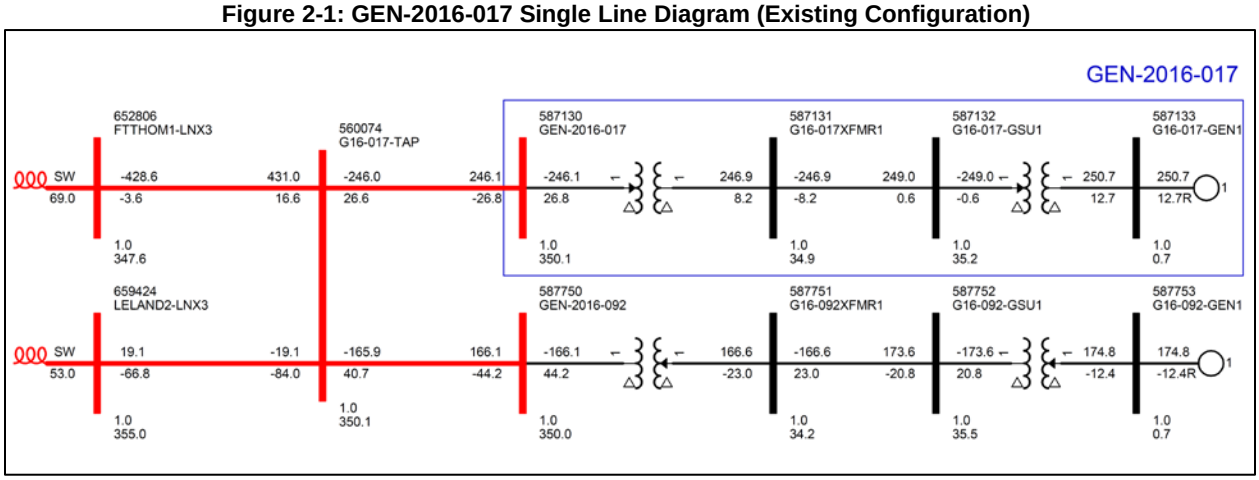
1.2 Study Limitations

The assessments and conclusions provided in this report are based on assumptions and information provided to Aneden by others. While the assumptions and information provided may be appropriate for the purposes of this report, Aneden does not guarantee that those conditions assumed will occur. In addition, Aneden did not independently verify the accuracy or completeness of the information provided. As such, the conclusions and results presented in this report may vary depending on the extent to which actual future conditions differ from the assumptions made or information used herein.

2.0 Project and Modification Request

GEN-2016-017 was originally studied as part of Group 15 in the DISIS-2016-001-3 study. Figure 2-1 shows the power flow model single line diagram for the existing GEN-2016-017 configuration.

Figure 2-1: GEN-2016-017 Single Line Diagram (Existing Configuration)



The GEN-2016-017 Modification Request included a turbine configuration change to a total of 92 x GE 2.72 MW wind turbines for total capacity of 250.24 MW. In addition, the modification request included changes to the collection system, generation step-up transformer, main substation transformer, and the generation interconnection line. The major modification request changes are shown in Figure 2-2 and Table 2-1 below.

Figure 2-2: GEN-2016-017 Single Line Diagram (New Configuration)

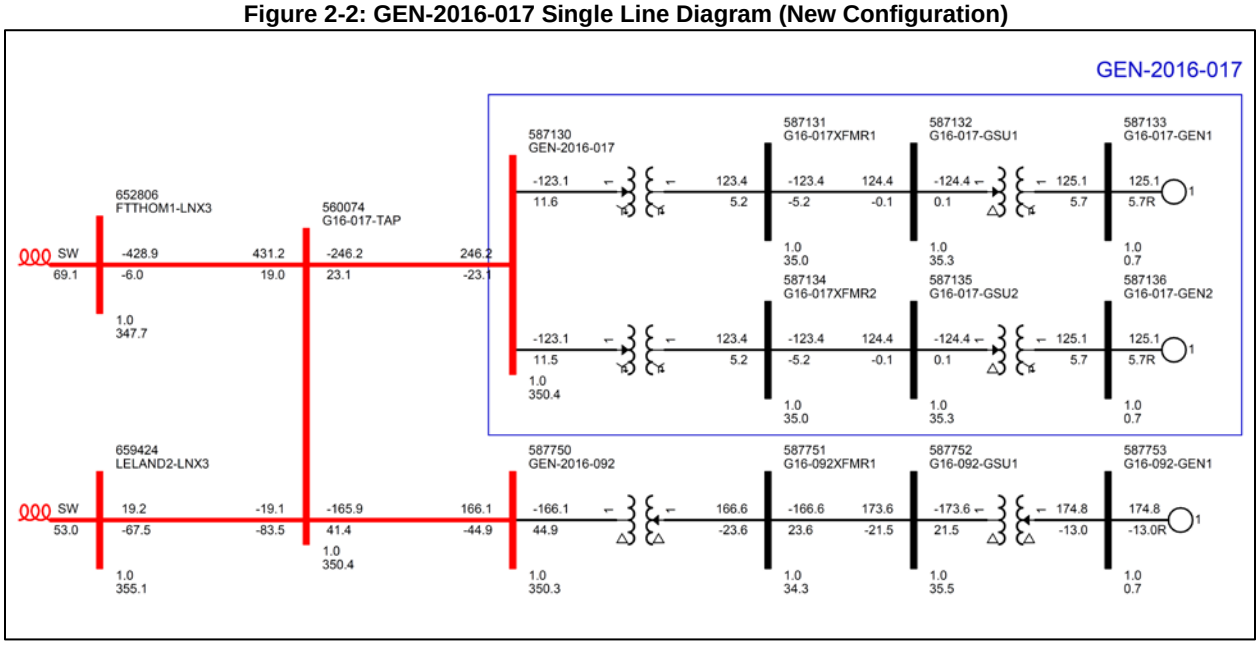


Table 2-1: GEN-2016-017 Modification Request

Facility	Existing	Modification	
Point of Interconnection	G16-017-TAP (560074) on Fort Thompson (652806) - Leland Olds (659424) 345 kV Line	G16-017-TAP (560074) on Ft. Thompson (652806) - Leland Olds (659424) 345 kV Line	
Configuration/Capacity	109 x GE 2.3MW = 250.7 MW	92 x GE 2.72MW = 250.24 MW	
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GSU Transformer	Gen 1 Equivalent Qty: 109: X = 5.69%, R = 0.8%, Rating 279.04 MVA	Gen 1 Equivalent Qty: 46: X = 5.68%, R = 0.71%, Rating 144.26 MVA	Gen 2 Equivalent Qty: 46: X = 5.68%, R = 0.71%, Rating 144.26 MVA
Equivalent Collector Line	R = 0.003549 pu X = 0.005016 pu B = 0.101990 pu	R = 0.006619 pu X = 0.008577 pu B = 0.063178 pu	R = 0.006601pu X = 0.009188 pu B = 0.064461 pu

3.0 Equivalent Impedance Comparison

The equivalent impedance comparison was performed using the modified study models created using the DISIS-2016-002 ReStudy #1 2017WP, 2018SP, and 2026SP models. The methodology and results of the equivalent impedance comparison are described below. The analysis was completed using PSS/E version 33.7 software.

3.1 Methodology and Criteria

The impedances from all the components of the transmission lines, substation and step-up transformers, and equivalent collector line impedances were added in series for GEN-2016-017 before and after the modification request. The percentage increase in the impedances before and after the modification request were then compared. If the percentage increase was greater than 10%, additional dynamic stability analysis would be performed to assess the impact of the modification request.

3.2 Results

Table 3-1 shows the impedance differences before and after the modification request. Table 3-2 shows the increases in impedances from the original impedances to the modification request impedances. The results showed the that impedances increases were below 10%.

Table 3-1: GEN-2016-017 Impedance Comparisons

System Component	Existing Model Impedances (p.u.)			Modification Request Impedances (p.u.)		
	R	***X***		***R***	***X***	
Gen Tie Line from POI to GEN-2016-017	0.00003	0.00026		0.00000	0.00003	
GEN-2016-017 collector system equivalent	0.00355	0.00502		0.00661	0.00888	
	R	***X***	***MVA Base***	***R***	***X***	***MVA Base***
GEN-2016-017 Main Transformer @ 100 MVA	0.00140	0.05881	100	0.00103	0.05654	100
GEN-2016-017 Unit GSU @ 100 MVA Base	0.0029	0.0204	100	0.00246	0.01967	100
	R	***X***	***Z***	***R***	***X***	***Z***
Total Impedance from POI to Collector System	0.007850	0.084482	0.084846	0.010101	0.085127	0.085724

Table 3-2: GEN-2016-017 Combined Impedance Comparison

Interconnection Request	Existing Impedance Z (p.u.)	MRIS Impedance Z (p.u.)	Impedance Change Z (p.u.)
GEN-2016-017	8.48%	8.57%	1.03%

4.0 Reactive Power Analysis

The reactive power analysis, also known as the low-wind/no-wind condition analysis, was performed for GEN-2016-017 to determine the reactive power contribution from the project's interconnection line and collector transformer and cables during low/no wind conditions while the project is still connected to the grid and to size shunt reactors that would reduce the project reactive power contribution to the POI to approximately zero.

4.1 Methodology and Criteria

For the GEN-2016-017 project, the generators were switched out of service while other collector system elements remained in-service. A shunt reactor was tested at the collection substation 34.5 kV bus to set the MVAr flow into the POI to approximately zero.

4.2 Results

The results from the reactive power analysis showed that the GEN-2016-017 project required an approximately 12.9 MVAr shunt reactor at the project substation, to reduce the POI MVAr to zero. Figure 4-1 illustrates the shunt reactor size required to reduce the POI MVAr to approximately zero. Reactive compensation can be provided either by discrete reactive devices or by the generator itself if it possesses that capability.

Figure 4-1: GEN-2016-017 Single Line Diagram (Shunt Reactor)

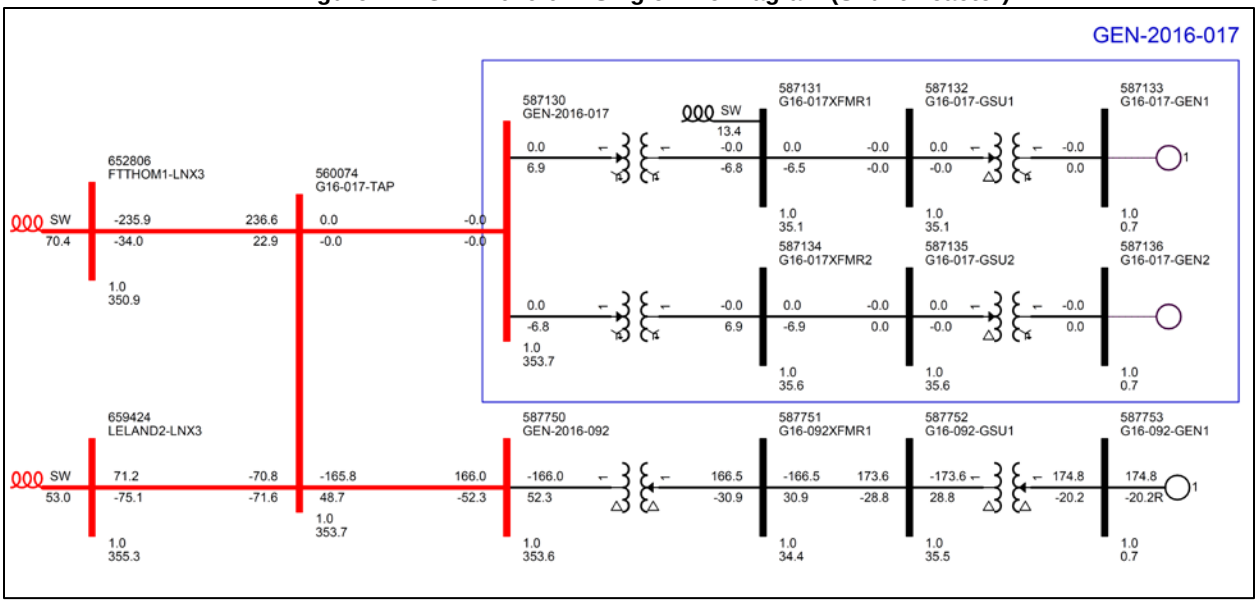

Table 4-1 shows the shunt reactor size determined for the three study models used in the assessment.

Table 4-1: Shunt Reactor Size for Low Wind Study

Machine	POI Bus Number	POI Bus Name	Reactor Size (MVAr)		
			17WP	18SP	26SP
GEN-2016-017	560074	G16-017-TAP	12.9	12.9	12.9

5.0 Conclusions

The Interconnection Customer for GEN-2016-017 requested a Modification Request Impact Study to assess the impact of the turbine and facility changes to a configuration with a total of 92 x GE 2.72 MW wind turbines for total capacity of 250.24 MW. In addition, the modification request included changes to the collection system, generator step-up transformer, main substation transformer, and the generation interconnection line.

The modification request resulted in a change in the equivalent impedances from the point of interconnection to the generator step up transformers of approximately 1.03%. As such a dynamic stability analysis was not deemed necessary and the scope of this modification request study was limited to the reactive power analysis (low wind) analysis.

A power factor analysis was not performed as there was no change in the point of interconnection for GEN-2016-017.

The results of the reactive power analysis, also known as the low-wind/no-wind condition analysis, performed using all three models showed that the GEN-2016-017 project required an approximately 12.9 MVAr shunt reactor on the 34.5 kV bus of the generator project substation. The shunt reactor is needed to reduce the reactive power transfer at the POI to approximately zero during low/no wind conditions while the generation interconnection project remains connected to the grid.